# AT THE ENTERPRISES AND INSTITUTES

UDC 666.3.022.002.237:621.928.8

## REMOVAL OF IRON-CONTAINING IMPURITIES USING THE MAGNETIC SEPARATION METHOD

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Translated from Steklo i Keramika, No. 1, pp. 28 – 29, January, 1999.

The methods of removal of iron-containing impurities from raw material are considered. In order to increase the efficiency of iron removal, dry refining of the raw material with self-cleaning roller-type separators with a magnetic system consisting of Nd – Fe – B permanent magnets is proposed. The installation of such separators will make it possible to remove from 50 to 90% of the iron-containing impurities present in the material.

The open character of the contemporary Russian market with its inevitable acute competition makes the problem of improvement of product quality vitally important for domestic manufacturers.

It is known that iron-containing impurities which are always present in the raw material worsen the exterior appearance of dishware, tiles, and sanitary ware and harm the physical parameters of insulators and refractories. Improvement of the quality and, consequently, the competitiveness of domestic ceramics is largely determined by a decrease in the amount of "fly-like" defects. This problem can be solved by acquiring costly imported machinery and, where necessary, imported technology and materials, which is inaccessible for many domestic producers. Another solution concerns upgrading of available machinery and requires much lower outlays. The latter solution in addition to providing financial advantages, also ensures the technical and economic independence of domestic manufacturing companies.

The traditional method of removal of iron-containing impurities from friable and liquid material is their removal in various magnetic separators or plants with powerful magnetic fields. The type, technical specifications and design of the equipment should be determined by the specifics of the particular technologic method of ceramic production, the parameters of the refined mixture flow, the initial impurity content, and the ratio between the initial and the required content.

The magnetic separation method is based on the effect of interaction of the magnetic particles in the material with an external magnetic field. The attraction force is described in the following way:

$$F \sim m\chi H \,\mathrm{grad}\, H$$

or

$$F\,(\,M(H)\,\mathrm{grad}\, H\,,$$

where $m$ and $\chi$ are the mass and the magnetic sensitivity of a particle; $H$ is the magnetic intensity; $\mathrm{grad}\, H$ is the magnetic field gradient (very approximately, it means the variation in the magnetic field per unit of length) developed by an electromagnet or permanent magnet system; $M(H)$ is the magnetization of an iron-containing particle in a magnetic field of intensity $H$.

Magnetization of highly magnetic compounds increases with an increase in the external magnetic field and attains a value known as saturation magnetization which for iron and carbon steel (known as ferromagnetics) is equal to about 2 T. The main iron-containing impurities are iron oxide particles (ferromagnets) with a magnetization degree of about 0.4 T, which are harder to remove than iron particles. The removal of finely disperse particles is also complicated by the strong inhibiting effect of the surrounding material.

To increase the efficiency of the removal of iron-containing impurities, it is necessary to design plants with magnetic systems which develop a very heterogeneous magnetic field of high intensity. The low magnetic characteristics of ferrite permanent magnets (residual induction of Br up to 0.4 T) do not allow for the development of high-gradient magnetic fields of high intensity. The systems with electromagnets are cumbersome, expensive to produce, maintain, and operate, and have a number of other limitations.

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0361-7610/99/0102-0032$22.00 

The ÉMKO Electromechanical Company uses the most powerful permanent magnets based on Nd – Fe – B designed by the company. The use of this type of magnet with high residual induction (up to 1,25 T), coercive force and energy made it possible to develop the optimum magnetic system design for separators and to increase their efficiency.

According to the available data, domestic manufacturers of ceramic articles do not remove iron-containing impurities from dry crushed material. It is expedient to equip this segment of the technological chain with self-cleaning separators of the roll type with a magnetic system consisting of Nd – Fe – B permanent magnets installed inside the last roll of the conveyor. Note that our company is the only one on the domestic market which offers roll separators for preliminary dry purification. Installation of this equipment will make it possible to remove 50 to 90% of the iron-containing impurities which are present in the initial raw material.

The removal of iron-containing particles over 0.1 mm in size at domestic ceramic works is carried out by cleaning of process suspensions in separators of the trough type based on ferrite permanent magnets which, however, are not able to ensure the required degree of purification. A comparison of the technical specifications of trough separators based on ferrite magnets (magnetic field intensity no greater than 0.15 T with a gradient of 0.02 T/cm) to the separators offered by our company based on Nd – Fe – B magnets and the optimum design (magnetic field intensity from 0.4 to 0.8 T with a gradient from 0.3 to 0.7 T/cm) confirms the advisability of replacing the existing separators with the separators produced by the ÉMKO which provide for a 10 – 100 times higher attraction force (force of holding impurity particles).

High-quality fine purification of technological suspensions from iron-containing impurities below 0.1 mm in size is carried out in multigradient magnetic separators which are used after preliminary purification of the suspensions. Their functioning principle is as follows: the suspension passes through a system of working bodies made of magnetic soft materials (special grid layers, balls) located in a magnetic field, and is purified of finely disperse impurities. The main disadvantage of this type of separator is that the cartridge with the working bodies soon get stuffed with impurities and stops functioning. The separators used abroad include a system with removable cartridges installed on a rotor mechanism which consecutively replaces the cartridges in operation. The size of such a plant is at least $3 \times 3 \times 2.5$ m, and their prices are several hundred thousand dollars. Note that for the majority of domestic ceramic manufacturers, the removal of iron-containing particles whose sizes are several tens of microns is not a top priority issue, and the high cost and low reliability of the respective equipment make it considerably less interesting.

Currently domestic producers do not use dry purification of raw materials from iron-containing impurities. The removal of impurities from suspensions is implemented by low-efficiency trough-type separators with ferrite magnets, which does not allow for adequate removal of particles over 0.1 mm in size, and the use of multigradient separators for high-quality fine purification appears to be a problematic, not very probable and very costly solution. What could be recommended in these circumstances?

The goal of a considerable decrease in the content of the iron-bearing impurities in domestic ceramics and substantial improvement of product quality and, accordingly, an increase in its competitiveness can be accomplished by use of the highly efficient magnetic separators produced by the ÉMKO company. Our specialists, after studying the specific conditions at your enterprises, will find the most effective and inexpensive technical solutions for equipping existing machinery with the magnetic separators described above or other separators of original design. The upgrade will make it possible to eliminate visible iron-containing inclusions in your products and to significantly decrease the iron content in ceramics.

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